# New Platinum Nanocrystal-Based Silicon Nanotubes for Targeting Breast Cancer

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## I. Introduction

Cancer is a major cause of death worldwide, and every year millions of people are diagnosed with it. Platinum compounds play an important role as anticancer agents. Their ability to bind to DNA in the nucleus (by a process known as intercalation within DNA base pairs) result in DNA damage and cell death.

Our research group has developed a straightforward method to produce a well-defined nanoscale drug carrier known as silicon nanotubes (SINTs), along with a way to incorporate platinum on their surface using (3-Aminopropyl) triethoxysilane (APTES) as a functional arm. These silicon nanotubes have attracted great attention in applications relevant to diagnosis and therapy, owing in part to its biocompatibility and biodegradability in cells.

## II. Methods

### A. Synthesis of Silicon Nanotubes (SiNTs)

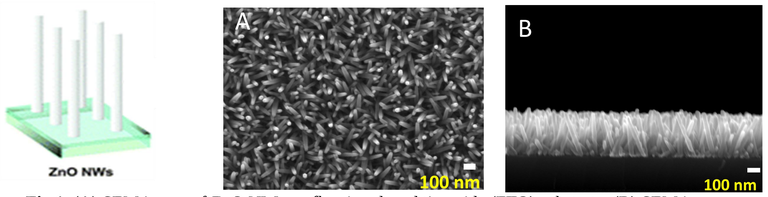


**Fig 1.** (A) SEM image of ZnO NWs on fluorine-doped tin oxide (FTO) substrate; (B) SEM image cross-section of ZnO NWs on FTO substrate. Growth of ZnO NWs at 95◦C.

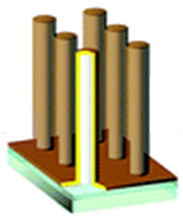

**Fig 2.** Si/ZnO NWs

**Deposition of Si on ZnO Nws via chemical vapor deposition of $SiH_4$ at 543 ◦C.**

$$SiH_{4(g)} \longrightarrow Si_{(s)} + 2H_{2(g)}$$

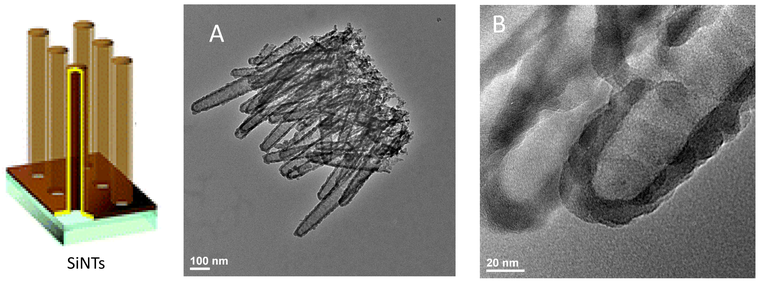


**Fig 3** (A) TEM image Silicon Nanotubes (SiNTs) low magnification; (B) Higher magnification

**Removal of ZnO NWs to produce hollow SiNTs**

$$ZnO_{(s)} + 2HCl_{(g)} \rightarrow ZnCl_{2(s)} + H_2O_{(g)} \quad (1)$$

$$ZnCl_{2(s)} + NH_{3(g)} \rightarrow Zn(NH_2)Cl_{(g)} + HCl_{(g)} \quad (2)$$

### B. Formation of Pt Nanocrystals on SiNTs

#### 1. Functionalization of SiNTs with primary amino groups using APTES

Zeta Potential analysis was performed to evaluate the surface charge of SiNTs before and after APTES functionalization.

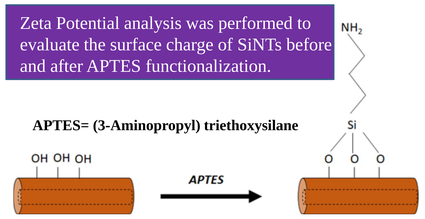


**Fig 4.** Scheme of functionalization of SiNTs with 2% of APTES in Toluene for 4 h at room temperature

**Table 1.** Zeta Potential of SiNTs before and after functionalization in DI water at pH 6.5

| Samples | Zeta Potential (mV) |
|---|---|
| Unmodified SiNTs | -17.04 ± 0.70 |
| APTES-functionalized SiNTs | +35.87 ± 1.96 |

#### 2. Incubation of APTES-SiNTs in $K_2PtCl_4$ solution at room temperature.

Incubation of APTES-SiNTs was for 24 h 1.5 mM $K_2PtCl_4$ solution at room Temperature

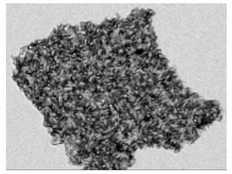

**Table 2**. Elemental analysis of Bundle PtNCs-SiNTs (TEM-EDX)

| Element | Wt% |
|---|---|
| Oxygen (O) | 10.64 |
| Silicon (Si) | 36.80 |
| Platinum (Pt) | 51.64 |
| Chlorine (Cl) | 0.93 |

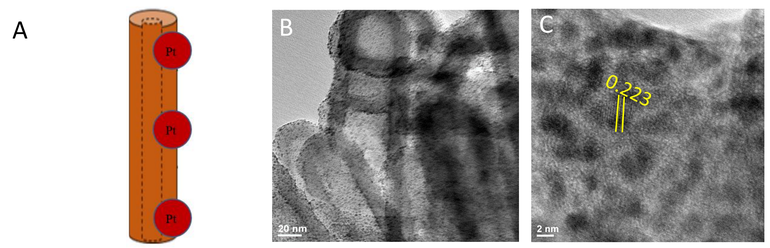


**Fig 5**. (A) Scheme of platination of APTES-SiNTs with $K_2PtCl_4$; (B) TEM image of PtNCs-SiNTs low magnification; (C) TEM image of PtNCs-SiNTs highlining the lattice spacing lines.

## III. Results

### A. Evaluation of Cell Viability of HeLa Cells after Treatment with Pt NCs-pSiNTs (Dr. Nguyen Le.)

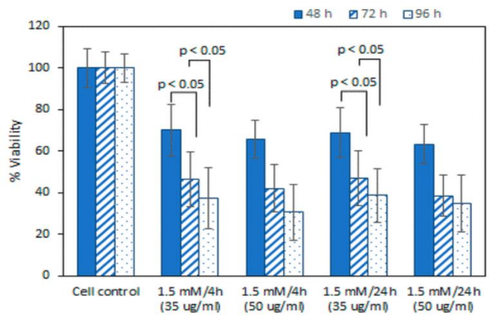


**Fig 6**. Cell viability after treatment with PtNCs-SiNTs at different doses (2)

### B. Folic Acid as a promising strategy in carcer treatment to direct the molecule-drug

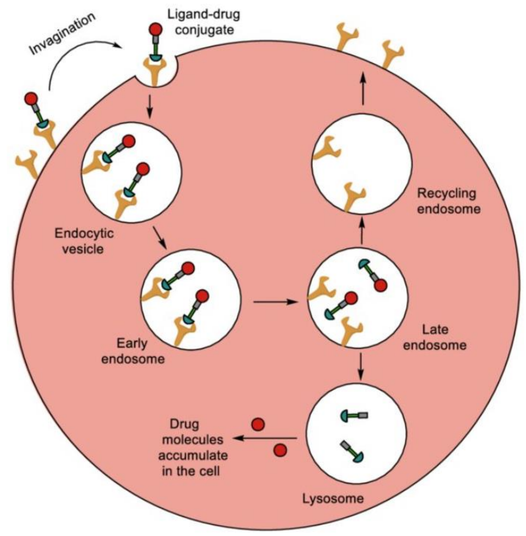


**Fig 7.** Receptor-mediated endocytosis of a Folate drug-conjugate (3)

### C. Conjugation of PtNCs-SiNTs with Folate

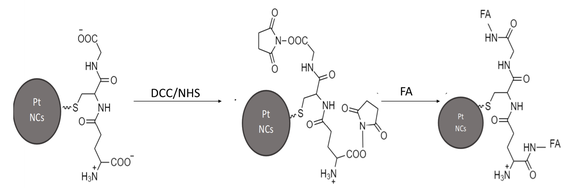


**Fig 8**. Scheme of Folic Acid attachment with PtNCs

**Table 3**. Zeta Potential in DI water at pH 6.5

| Samples | Zeta Potential (mv) |
|---|---|
| PtNCs-SiNTs | -28.05 ±0.67 |
| GSH-PtNCs-SiNTs | -42.38 ±2.22 |
| Folate-GHS-PtNCs-SiNTs | -18.45 ±0.93 |

## IV. Conclusions and Future Work

- The properties of this material have a high toxicity against HeLa cells inducing apoptosis.
- Results of Zeta potential indicate an attachment of Folate to the PtNCs.
- The next step is performing the X-ray Photoelectron Spectroscopy (XPS) to confirm the attachment with folate

## V. References

1. Xuezhen Huang, Roberto Gonzalez-Rodriguez, Ryan Rich, Zygmunt Gryczynski and Jeffery L. Coffer. *Chem. Commun.*, **2013**,49, 5760-5762
2. Nguyen T. Le; , Giridhar R. Akkaraju and Jeffery L. Coffer. *ACS Appl. Bio Mater.* 2020, 3, 1, 208–216
3. Marcos Fernandez; Faiza Javaid and Vijay Chudasama.Chem Sci. 2018 Jan 28; 9(4): 790–810

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